Chapter 15
Autonomous Multifunctional Quadcopter for Real-Time Object Tracking and Seed Bombing in a Dynamic Environment

Pratham Nar, Shashank Sadanand Amin, Sashwata Banerjee, Vaibhav Garg and Arjun Pardasani

Abstract In recent years, a staggering increase in the development and use of unmanned aerial vehicles has been noticed in a comprehensive range of applications. This paper is based on the utilization of autonomous quadcopter in plantation monitoring (Krishna in Agricultural drones: a peaceful Pursuit, [1]). Agricultural drones are set to revolutionize the global food generation system. Agricultural drones are already flocking and hovering over farms situated in a few agrarian zones. This quadcopter will autonomously navigate, avoid collisions and collect data using computer vision for post-analysis and drop seeds in specified locations. Using aerial quadcopter for surveying vast agricultural land can reduce human efforts. The quadcopter is designed to detect moving objects and identify rodents using an object recognition method. The motive of the paper is to design a low-cost unmanned autonomous aerial vehicle system which will accurately and efficiently locate potential threats and notify the owners about their location and severity.

Keywords Quadcopter · Computer vision · IoT · OpenCV · Seed bombing

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15.1 Introduction

Agriculture plays a crucial role in a country's development. Agriculture provides us with raw food materials to consume. It is also the cornerstone of economic system of a country. It contributes majorly to the national income. It also furnishes people with products of export, thereby helping in economic upswing. Present global population is around 7.6 billion, and it is estimated that it will reach 9 billion by 2050.

With rise in population, demand for food will also increase. To cater the need of the billions of people, there must be a boom in the production of raw materials and food materials. There are several factors which hinder the agricultural production, for example, extreme weather conditions, unavailability of water, excessive use of pesticides, invasive species like pests and diseases. One more major drawback is the decrease of human labour. It is evident that we need revolutionary technological strategies to be applied in the field of agriculture not only to increase its production but also to automate the process of farming and to monitor crops. The segmentation of images also plays an important role in achieving the desired result [2].

Unmanned aerial vehicles or drones are used since the 1990s, it now has a broad field of applications, and recently drones are being widely used in the field of precision agriculture. UAV or drones have become common to farmers, and they are utilizing them for crop monitoring, livestock monitoring and transporting items from one point to another. Using drone has many advantages over manual farming. It helps in getting a better view of the field and can monitor a large area in short span of time. Modern-day drones come with lots of sensors to get more details of the field so that one can know what crops are affected, and how much water and pesticide they need. Nowadays, most advanced systems fuse information gained from various sensors for both localization (position) and navigation purposes [3].

This saves lots of water, and soil contamination is less as usage of pesticide decreases.

To increase the crop yield, crops need proper pesticides and exact amount of water. As data is gathered, the parameter estimates are refined and the trajectory is improved. An illustrative example is given to demonstrate to capability of the method [4]. Drones can carry waters and fertilizers and can spray it on a large scale. This saves a lot of time and money for the farmer. Using infrared sensors in drones, one can know the health of the crop and can act accordingly. Drones can use cameras to survey which part of the field requires more water and can monitor livestock. To accomplish all these tasks, it is needed to develop a system capable of controlling and navigating the UAV in an unknown environment using only On-board sensors, without markers or calibration objects [2].

We worked on a drone system which can be utilized in farming. The drone we developed is an autonomous one and hence does not require any pilot to control it. It can survey large areas and can spray water from the cache attached on it. It can also drop seeds and pesticides, can check soil moisture level and can also detect potential threats to the crop. Thus, it can be used for efficient farming with reduced labour cost and consuming lesser time. The use of multiple collaborative robots is ideally

Fig. 15.1 CAD render of the developed drone

suited for such tasks. A major thrust within this area is the optimal control and use of robotic resources to reliably and efficiently achieve the goal at hand [5].

15.2 Motivation

Agriculture suffers from a great deal of problems. Excessive use of water and fertilizers may result in damage of crops. It is impossible to constantly monitor large areas of agricultural land and protect them. Moreover, some parts of the field may require lesser water, whereas some parts may require more. We developed a drone keeping all the drawbacks in mind and tried to come up with a viable solution. We developed an autonomous drone which can survey and transfer data wirelessly. Our main objective was to reduce human effort by integrating two major contemporary technologies, namely UAV and Internet of things. The drone which we proposed can monitor crops, spray water as per requirement, plant seeds and detect potential threats [2]. This work presents a systematic review that aims to identify the applicability of computer vision in precision agriculture.

15.3 Design

15.3.1 System Design

The below diagram describes the physical layout of quadcopter (Fig. 15.1).

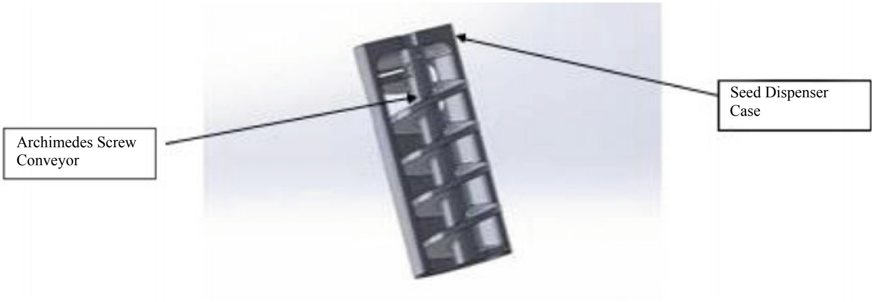


Fig. 15.2 Sectioned view of the seed dropper CAD model

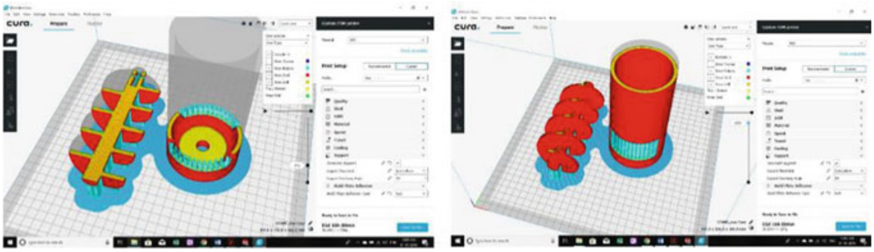


Fig. 15.3 Sliced layer view on the Cura slicer

15.3.2 *Seed Bombing Mechanism*

Physical Layout:

See Fig. 15.2.

Description of the seed dropping mechanism:
The design of the seed dropper was done on SolidWorks. It consists of an Archimedes screw with a length of 136 mm and a pitch of 30 mm completing 4.5 revolutions. It has a diameter of 65 mm. The pitch was given such that the seeds would not drop when the motor was switched off due to the slope and friction against the surface.

The seed dropper also consists of a case that has two openings at the bottom used for deploying the seeds in both directions.

The design was sliced on a 3D printing slicer called Ultimaker Cura with a tri-hexagon 50% infill and 3 shells printed at a 0.2-mm layer height. The total weight of the parts was 193 g and took 10 h to print. The part was made of ABS.

The dropping mechanism consists of the 3D printed Archimedes screw and case, a 12 V DC motor and balsa plate at the bottom to prevent seeds from getting stuck and facilitating easy deployment (Figs. 15.3 and 15.4).

Fig. 15.4 Three-dimensional printed seed dropper

15.3.3 Hardware

- Drone frame
- 4 × brushless DC motors
- Electronic speed controller
- Flight controller
- Power distribution board
- Receiver module X6B
- Transmitter
- Battery: LIPO
- Soil moisture sensor
- Infrared camera
- Bluetooth module
- Seed bombing mechanism
- Water storage area.

15.3.4 System Architecture

See Fig. 15.5.

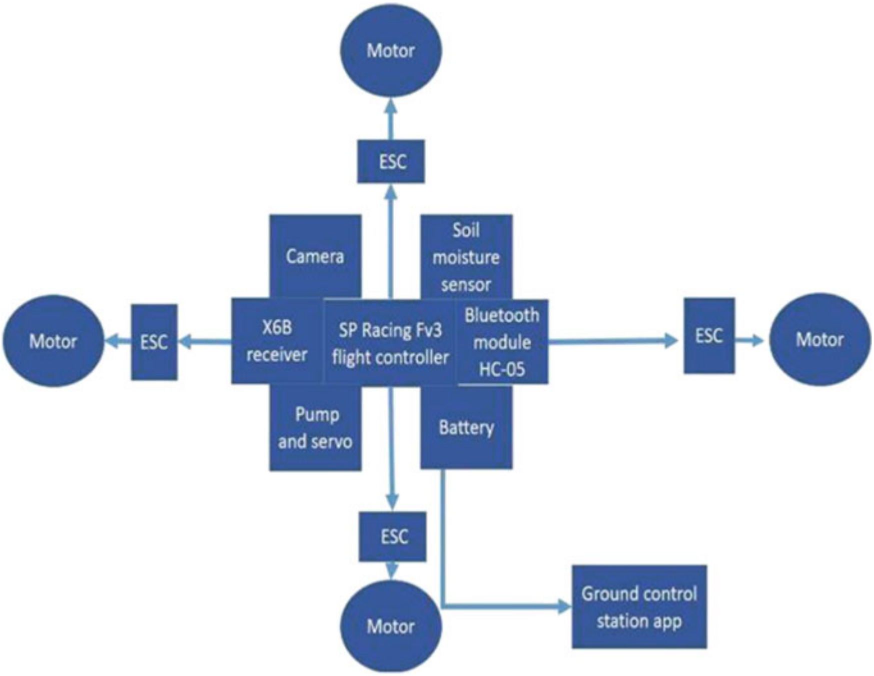


Fig. 15.5 Diagram of the system architecture of quadcopter

15.4 Methodology

The drone we proposed is an autonomous drone and can be controlled remotely by using an application. The drone uses GPS to autonomously move from a point to another which is set by the user. The GPS input is a waypoint co-ordinate input which is fed into the algorithm.

Algorithm

The algorithm is developed to make sure it does not collide with any obstacle on its way and simultaneously scanning the field. After the drone is turned on, it first checks the battery life. If the battery is sufficient, it proceeds with the next step, i.e. checking for its current longitude and altitude. According to the GPS co-ordinates set by the user, it plans its trajectory in such a way to avoid obstacles in its way. After reaching its destined location, it activates its camera. He mission planner component generates routes for individual [6]. It can also land down to check the soil moisture if asked by the user. The drone has the capability to drop seeds, spray water and pesticides and check for rodents in the farm. It can detect objects using a camera and process the images in real time to identify a potential threat to the crop which can be a rodent. This can be done by capturing the image first and then tracking objects in it. Then, the tracked object is identified by image classification technique. This entire process is done in a dynamic environment. Improvements are needed regarding flight length, camera vibration image acquisition and provision of the possibility of autonomous take-off and landing [7].

Software

We developed a mobile application which displays the telemetry sensor data acquired from the Bluetooth module positioned on the drone (Figs. 15.6 and 15.7).

The on-board Bluetooth module (HC-05) transmits the telemetry data to the Bluetooth connected node on a cellular device. This developed application is used to view the data.

The console software is used to change the configuration of the drone. Alongside telemetry data, the software also shows the yaw, pitch and roll of the drone (Fig. 15.8). The algorithm has been optimized for embedded CPUs commonly employed in lightweight robotic platforms [8].

15.5 Results

The following table describes the yaw, pitch and roll setting on the quadcopter and gives a real-time plot of it (Figs. 15.9, 15.10 and 15.11).

The algorithm is implemented to recognize particular symbols and send the current location of the drone to the mobile application. The process of dropping the seeds is controlled by means of a feedback from the wireless sensor network deployed at the seed container using the servo attached. The sample video is of a flying micro-drone in a room. The algorithm was able to accurately detect the multiple symbols in the two-minute video, regardless of the picture quality (Figs. 15.12, 15.13 and 15.14). Image preprocessing plays a central role that significantly impacts to the results of any classifiers [9].

Fig. 15.6 Diagram of the developed algorithm for autonomous drone navigation

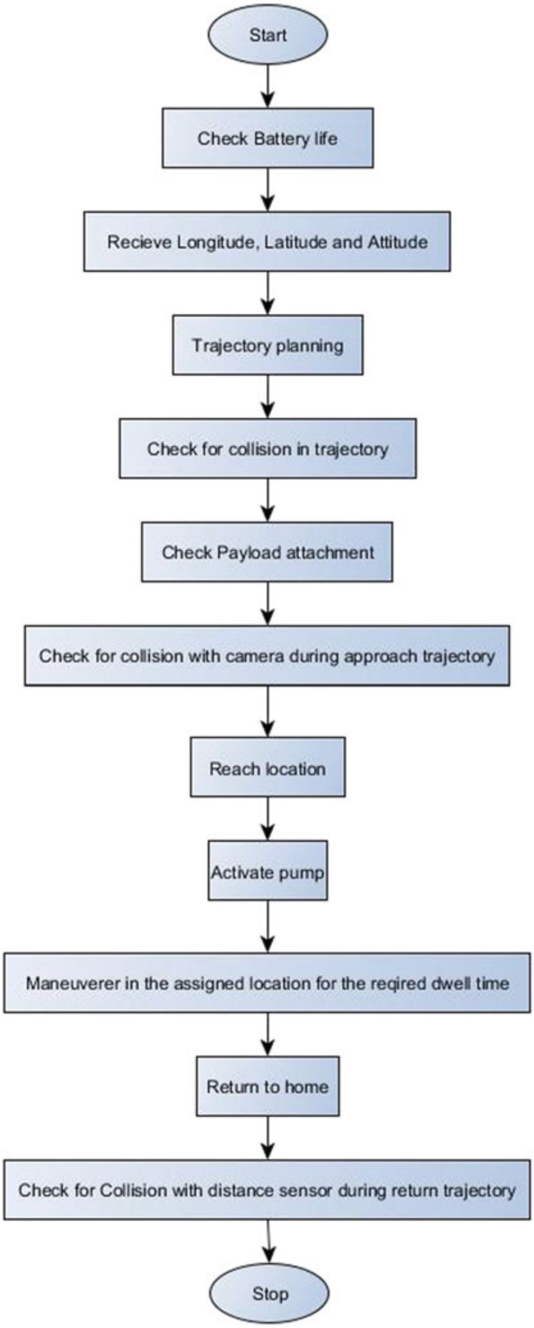
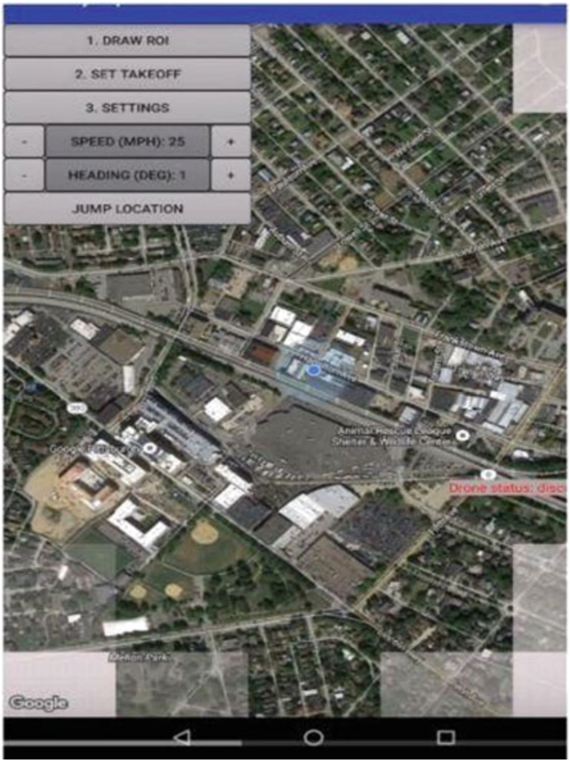


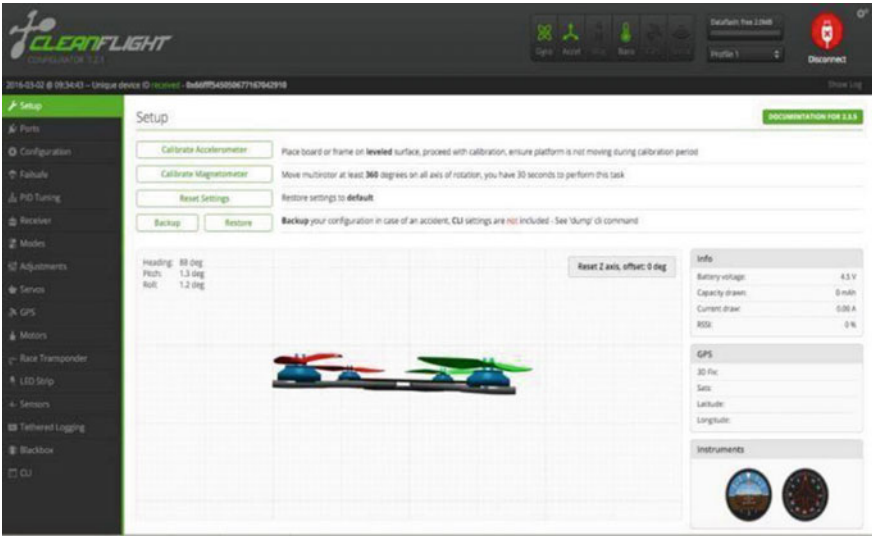
Fig. 15.7 Application



SPEED (MPH): 25

HEADING (DEG): 1

Drone status: disc



2016-03-02 @ 09:34:43 – Unique device ID received

Setup

Place board or frame on **leveled** surface, proceed with calibration, ensure platform is not moving during calibration period

Move multirotor at least **360** degrees on all axis of rotation, you have 30 seconds to perform this task

Restore settings to **default**

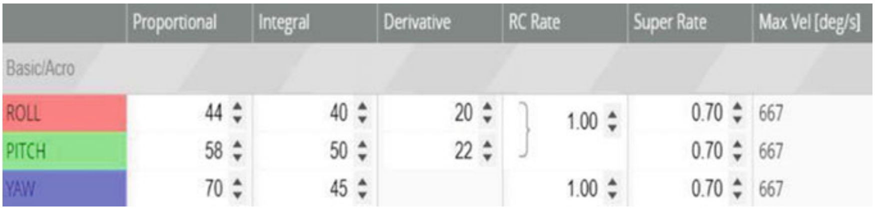
Backup your configuration in case of an accident, **CLI** settings are not included - See 'dump' cli command

Heading: 88 deg
Pitch: 1.3 deg
Roll: 1.2 deg

Info
Battery voltage: 4.5 V
Capacity drawn: 0 mAh
Current draw: 0.00 A
RSSI: 0 %

GPS
3D Fix:
Sats:
Latitude:
Longitude:

Fig. 15.8 Console software



	Proportional	Integral	Derivative	RC Rate	Super Rate	Max Vel [deg/s]
Basic/Acro						
ROLL	44	40	20	1.00	0.70	667
PITCH	58	50	22		0.70	667
YAW	70	45		1.00	0.70	667

Fig. 15.9 Yaw, pitch and roll settings for the drone

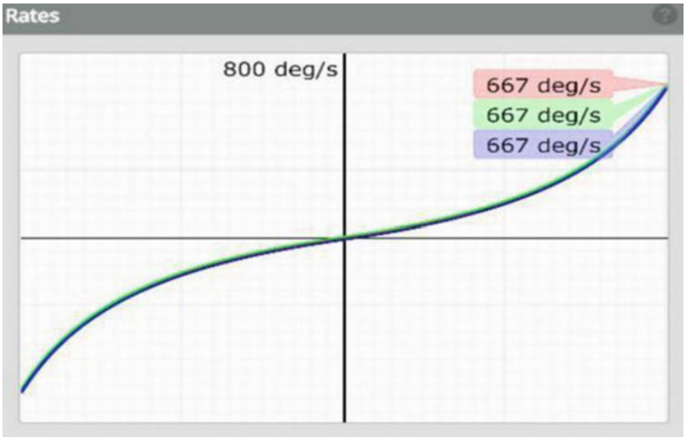
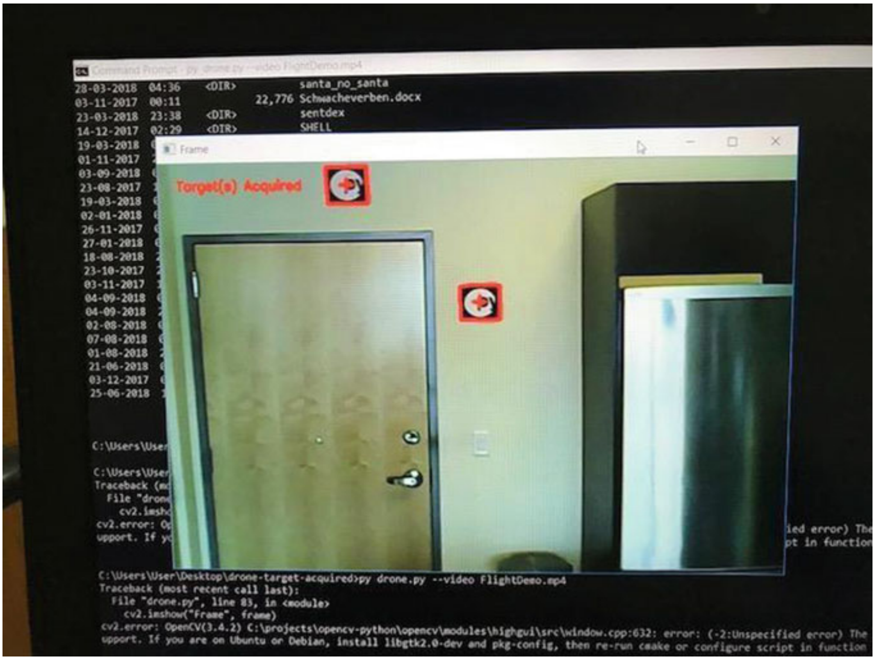


Fig. 15.10 Yaw, pitch and roll versus time graph

Fig. 15.11 Testing of the seed bombing mechanism



```
28-03-2018  04:36    <DIR>          santa_no_santa
03-11-2017  00:11            22,776 Schwacheverben.docx
23-03-2018  23:38    <DIR>          sentdex
14-12-2017  02:29    <DIR>          SHELL
19-03-2018
01-11-2017
03-09-2018
23-08-2017
19-03-2018
02-01-2018
26-11-2017
27-01-2018
18-08-2018
23-10-2017
03-11-2017
04-09-2018
04-09-2018
02-08-2018
07-08-2018
01-08-2018
21-06-2018
03-12-2017
25-06-2018


C:\Users\Use

C:\Users\User
Traceback (m
  File "dron
    cv2.imsho
cv2.error: Op                                                              ied error) The
upport. If yo                                                              pt in function

C:\Users\User\Desktop\drone-target-acquired>py drone.py --video FlightDemo.mp4
Traceback (most recent call last):
  File "drone.py", line 83, in <module>
    cv2.imshow("Frame", frame)
cv2.error: OpenCV(3.4.2) C:\projects\opencv-python\opencv\modules\highgui\src\window.cpp:632: error: (-2:Unspecified error) The
upport. If you are on Ubuntu or Debian, install libgtk2.0-dev and pkg-config, then re-run cmake or configure script in function
```

Fig. 15.12 Implementation of the object tracking algorithm

Fig. 15.13 Side view of the assembled quadcopter

Fig. 15.14 Top view of the assembled quadcopter

We manufactured the U-shaped landing gear from section cut-outs of large diameter PVC pipes. These circular cut-outs were cut in half and then moulded into shape using boiling water. Zip ties were used to attach the landing gear to the quadcopter.

This type of landing gear is used to give sufficient ground clearance for the seed dropper and other equipment attached to the bottom of the drone.

15.6 Conclusion

Farming requires a lot of manual labour in areas such as the distribution of seeds on the field, countering pests and monitoring the water requirement of every crop. The soil moisture and quality are some of the reasons that force us to shift towards the modern ways of farming. The "autonomous multifunctional quadcopter" embedded with the technologies like object detection and algorithms to spread seeds while avoiding a collision. The drone also has the ability to detect rodents using image processing. It also has the ability to check the soil and provide a practical solution to these problems. Assisted natural regeneration (ANR) will play a vital role in assisting the United Nations target, to restore degraded forest land to 350 million hectares, by 2030. In fact, they provide a low-cost solution for imagery collection, and the small size and manoeuvrability makes UAVs a viable and low-cost option [10].

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